

Arthroscopic Single-Row Superior Capsular Reconstruction for Irreparable Rotator Cuff Tears



Travis S. Roth, M.D., M.S., Matthew L. Welsh, M.D., Daryl C. Osbahr, M.D., and Amit Varma, M.D.

Abstract: Massive, irreparable rotator cuff tears are challenging to manage. Often, these tears are not amenable to primary repair and necessitate additional treatment options. This is especially true in patients with absent glenohumeral arthritis in the setting of a massive, irreparable rotator cuff tear. Superior capsular reconstruction (SCR), originally described by Mihata using a fascia lata autograft, has grown in popularity for the treatment of irreparable rotator cuff tears as a salvage option with good clinical outcomes. More recently, SCR techniques have been described using dermal allograft. Biomechanical studies and reported clinical series show promising results, with favorable postoperative clinical outcomes. The procedure, however, may be technically challenging, especially when performed using an all-arthroscopic technique. This article describes an all-arthroscopic technique using a predetermined graft size, unique medial fixation to ease graft passage, and knotless single-row lateral fixation to optimize suture management and efficiency.

Rotator cuff repair is one of the most common orthopaedic procedures, performed at a very high rate over the past decade.^{1,2} Advanced surgical techniques and improved patient outcomes have supported the growing trend toward rotator cuff repair.³⁻⁵ Although most tears, including large and massive tears, can be primarily repaired, a certain subset of irreparable tears pose a unique surgical challenge. Frequently, these tears comprise retracted, poor-quality tissue not amenable to adequate primary tendon-to-bone repair. Consequently, attempted primary repair is associated with high failure rates and poor outcomes.⁶⁻¹⁰

Whereas some authors have advocated for reverse shoulder arthroplasty (RSA) in this surgical scenario, this treatment overlooks the common presentation of relatively younger patients with absent to minimal glenohumeral arthritis in the setting of an irreparable rotator cuff tear.¹¹ RSA also commits permanent destruction of glenohumeral cartilage and may be associated with multiple complications including concerns over implant longevity.^{12,13} Additional treatment options for irreparable tears or previously failed rotator cuff repairs include debridement with or without biceps tenodesis or tenotomy, revision repair with or without patch augmentation, partial rotator cuff repair, tendon transfer, or superior capsular reconstruction (SCR). SCR involves bridging the tissue gap of massive, irreparable rotator cuff tears using fascia lata autograft or human dermal allograft to prevent superior migration of the humeral head and subsequent rotator cuff arthropathy. Mihata et al.¹⁴ originally described the SCR technique utilizing fascia lata autograft with promising results. Since then, similar techniques using dermal allograft have been described.¹⁵⁻¹⁸ Recent clinical series have also been performed using dermal allograft, including preliminary studies that reported encouraging results at 1-year follow-up and another which showed significantly improved clinical and radiographic outcomes at 2-year follow-up.¹⁹⁻²¹ Given the growing popularity of SCR among shoulder surgeons, we anticipate similar reports in the near future.

From the American Sports Medicine Institute, Birmingham, Alabama, U.S.A. (T.S.R.); the University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, U.S.A. (M.L.W.); the Orlando Health Orthopaedic Institute, Orlando, Florida, U.S.A. (D.C.O.); and the Florida Sports Injury & Orthopaedic Institute, Clermont, Florida, U.S.A. (A.V.).

The authors report the following potential conflicts of interest or sources of funding: D.C.O. is a consultant for Arthrex. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received November 13, 2019; accepted January 25, 2020.

Address correspondence to Travis S. Roth, M.D., M.S., American Sports Medicine Institute, 805 St. Vincent's Dr, Birmingham, AL 35205, U.S.A. E-mail: travisroth14@gmail.com

© 2020 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/191389

<https://doi.org/10.1016/j.eats.2020.01.024>

Technique

The patient is positioned in the beach chair position. A diagnostic arthroscopy is performed, revealing a massive, retracted rotator cuff tear. Biceps tenodesis is performed, if necessary, whereas tenotomy is typically avoided, as the long head of the biceps tendon is known to serve as a humeral head depressor. Once SCR has been chosen after identification of a massive, irreparable rotator cuff tear, intra-articular preparation of the glenoid is performed. Through the anterior portal, the superior labrum is elevated, and the superior glenoid neck medial to the labrum is debrided of soft tissue to a bed of bleeding bone with either a shaver or motorized burr similar to preparation for a labral repair (Figure 1).

Attention is then directed to the subacromial space. A decompression and acromioplasty are performed to enhance visualization. The coracoacromial ligament is left intact to help prevent anterosuperior escape of the humeral head in the event of SCR failure. Often the massive rotator cuff tear is retracted medially to the level of the glenoid. A tissue grasper introduced from the lateral portal confirms irreducibility of the tear to its greater tuberosity footprint. Occasionally, a massive, highly retracted tear can be advanced back to the footprint after a significant lysis of adhesions with or without anterior/posterior interval slide. After subacromial decompression, the footprint of the greater tuberosity is prepared in similar fashion to rotator cuff repair, using a motorized burr to reach a bleeding bed of bone (Figure 2).

A standardized graft preparation technique increases efficiency in our experience. The graft is prepared on the back table of the operating room. The 40 × 70 × 3-mm ArthroFLEX Decellularized Dermal Allograft (Arthrex, Naples, FL) is used. The graft is precisely measured and cut to a trapezoidal shape measuring 25 mm medially and 30 mm on the 3 remaining sides. Sutures for fixation of the graft to the greater tuberosity

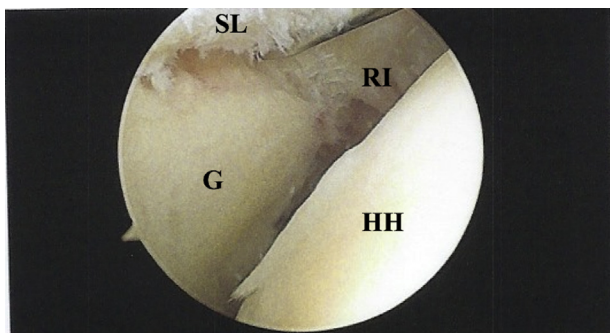


Figure 1. Right shoulder in the beach chair position viewing from the posterior portal within the glenohumeral joint. The superior glenoid rim beneath the superior labrum has been prepared with a motorized shaver before medial anchor placement. SL, superior labrum; G, glenoid; HH, humeral head; RI, rotator interval.

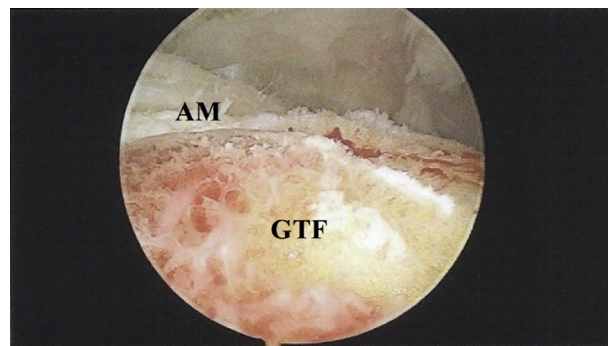


Figure 2. Right shoulder in the beach chair position viewing from the posterior portal within the subacromial space. The greater tuberosity has been prepared to a bleeding bed of bone with a motorized shaver before graft passage and anchor placement. GTF, greater tuberosity footprint of rotator cuff; AM, articular margin of humeral head.

(single row) are passed at this time. Two #0 TigerLink sutures (Arthrex) are passed consecutively through the anterior side of the lateral aspect of the graft using a Scorpion suture passer (Arthrex). Two #0 FiberLink sutures (Arthrex) are passed through the posterior side of the lateral aspect of the graft in the same manner. All sutures are passed with ~5 mm of graft between suture and graft edge.

Attention is again turned to the subacromial space. A 12-mm PassPort cannula (Arthrex) is split longitudinally with scissors and placed into the lateral portal to facilitate anchor and graft passage. One 4.5 × 14-mm Bio-Corkscrew FT suture anchor with two #2 FiberWire sutures (Arthrex) is inserted into the anterior superior glenoid. The blue FiberWire suture is removed, and the striped TigerWire suture remains. Similarly,

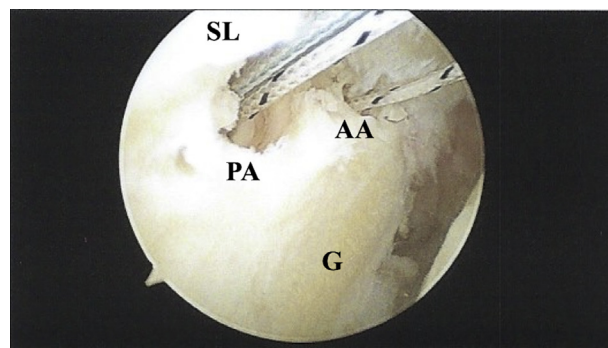


Figure 3. Right shoulder in the beach chair position viewing from the posterior portal within the glenohumeral joint. Anterior and posterior 4.5 × 14-mm Arthrex Bio-Corkscrew FT double-loaded suture anchors placed in the superior glenoid. The anterior anchor (AA) blue #2 FiberWire suture has been removed, leaving the striped #2 TigerWire for graft fixation. The posterior anchor (PA) is shown double-loaded; the striped #2 TigerWire suture will be removed, leaving the blue #2 FiberWire for graft fixation.

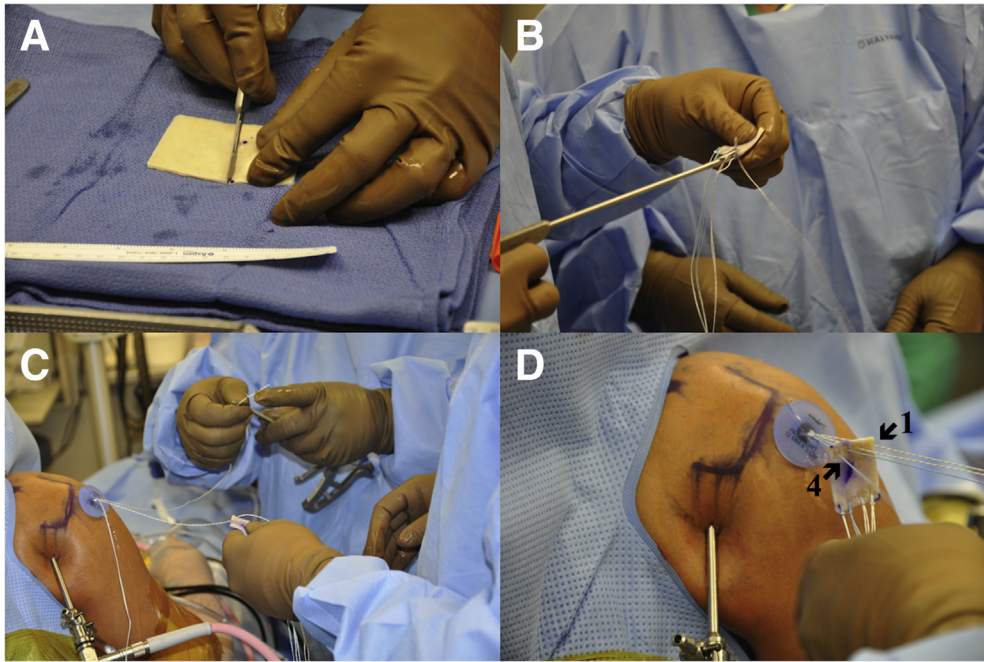


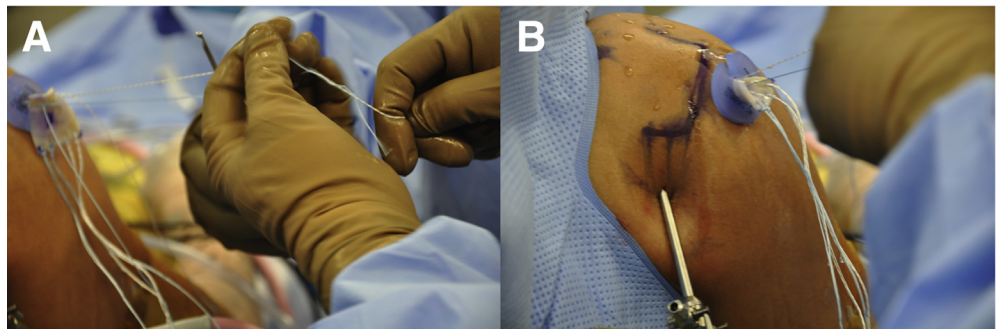
Figure 4. (A) Arthroflex ArthroFLEX graft prepared on back table of the operating room; graft measures 25 mm on medial (glenoid) side, 3 remaining sides measure 30 mm. (B) Sutures are passed through graft outside of the shoulder. Lateral sutures passed using Arthroflex Scorpion suture passer with two #0 TigerLink sutures anteriorly and two #0 FiberLink sutures posteriorly. Free suture tails are passed through their corresponding loop and snugged to the lateral graft edge. (C) Medial sutures passed using Arthroflex Scorpion suture passer with TigerWire sutures anteriorly and FiberWire sutures posteriorly. (D) All sutures passed before graft shuttling through Arthroflex 12-mm PassPort Cannula. Note that cannula is split longitudinally to facilitate graft passage. 1, medial suture 1; 4, medial suture 4.

another 4.5×14 -mm Bio-Corkscrew FT suture anchor is inserted into the posterior superior glenoid. The striped TigerWire suture is removed, and the blue FiberWire suture remains. The TigerWire and FiberWire sutures can be labeled numbers 1 to 4 from anterior to posterior for descriptive purposes. These sutures are retrieved out of the lateral portal (Figure 3).

Suture anchors placed in the glenoid are now available to pass through the graft outside of the shoulder. TigerWire sutures 1 and 2 are passed through the medial edge of the graft anteriorly via Scorpion suture passer. Similarly, the FiberWire sutures 3 and 4 are passed through the medial edge of the graft posteriorly

(Figure 4A-D). All sutures are passed with ~ 5 mm of graft between suture and graft edge. Sutures 2 and 4 are tied over an arthroscopic knot pusher with a series of half-hitch knots. Sutures 1 and 3 are then held in opposite hands and pulled sequentially to shuttle graft through the lateral portal to the glenoid (Figure 5A, B). This graft shuttling technique minimizes bunching or rolling of the graft. Occasionally, the PassPort cannula in the lateral portal must be removed to shuttle the graft if passage is at all hampered. A sterile towel can be placed on the lateral aspect of the shoulder to avoid contamination of the graft with skin flora during introduction. Sutures 1 and 3 are then shuttled out of

Figure 5. (A) Before graft passage into the shoulder, medial sutures 2 and 4 are tied over an arthroscopic knot pusher with a series of half-hitch knots. Suture tails are cut before graft passage. (B) Graft is shuttled into the shoulder through Arthroflex 12-mm Pass-Port cannula by sequentially tensioning sutures 1 and 3.



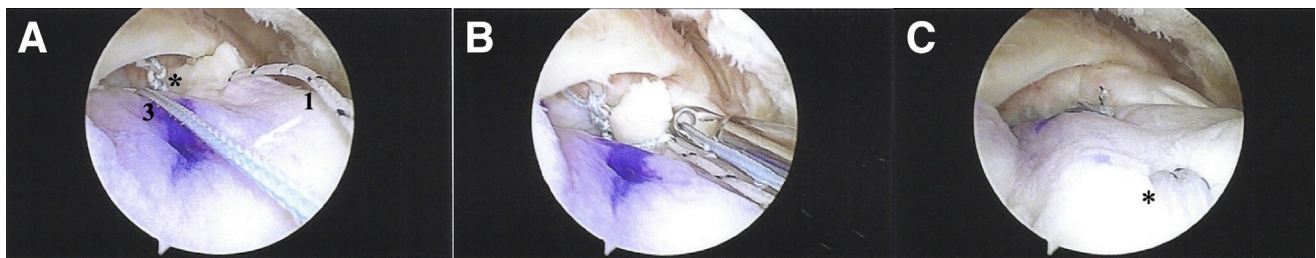


Figure 6. Right shoulder in the beach chair position viewing from the posterior portal within the subacromial space. (A) Graft snugged to glenoid with additional sequential tensioning of suture 1 (1) and suture 3 (3). Asterisk (*) denotes knot of sutures 2 and 4 previously tied and cut outside shoulder. (B) Sutures 1 and 3 tied with a series of half-hitch knots using an arthroscopic knot pusher. (C) Suture tails of sutures 1 and 3 cut with final glenoid fixation of graft. Asterisk (*) identifies previously placed TigerLink anterolateral suture.

an accessory anterior superolateral portal, using a cannula to prevent a soft tissue bridge. The graft is snugly opposed to the superior glenoid by gently pulling sutures 1 and 3. Finally, the graft is fixed medially on the glenoid by tying sutures 1 and 3 with a series of half-hitch knots (Figure 6A-C).

Fixation of the lateral aspect of the graft to the greater tuberosity is now addressed. The 2 anterior TigerLink sutures are shuttled out of the accessory anterior superolateral portal. These sutures are then fixed to the footprint anteriorly with desired graft tension, using a 4.75×19.1 -mm BioComposite SwiveLock C vented anchor (Arthrex). The 2 posterior FiberLink sutures are then similarly fixed to the footprint posteriorly with an additional 4.75×19.1 mm BioComposite SwiveLock C anchor through the lateral portal or an accessory superolateral portal created posteriorly (Figure 7A, B).

The arthroscope can be placed in the lateral or accessory superolateral portal to better visualize the graft placement. On occasion, the anterior or posterior edge of the graft may require another FiberLink or TigerLink and SwiveLock anchor to help maximize coverage of the tuberosity. In addition, side-to-side sutures between graft and residual supraspinatus anteriorly or infraspinatus posteriorly may be

performed to enhance force coupling of the shoulder (Video 1).

For rehabilitation during the first 4 weeks, the patient wears a sling, may perform pendulum exercises, and is encouraged to perform progressive elbow and wrist range of motion as tolerated. Between weeks 4 and 8, the patient is allowed passive and active-assisted shoulder range of motion. Active range of motion begins at 8 weeks. Full recovery of range of motion and strength is typically expected between 4 and 5 months postoperatively.

Discussion

A significant treatment dilemma arises in patients with massive, irreparable rotator cuff tears in the absence of glenohumeral arthropathy. Although it is tempting to consider RSA in this population, the treating surgeon should be aware of SCR as a salvage procedure to decrease pain, improve function, and potentially halt progression to rotator cuff arthropathy. RSA may be a viable option for these patients, but notable complication rates as high as 38% have been reported, particularly in patients under the age of 65 years.^{11,22,23} In our experience, SCR does not

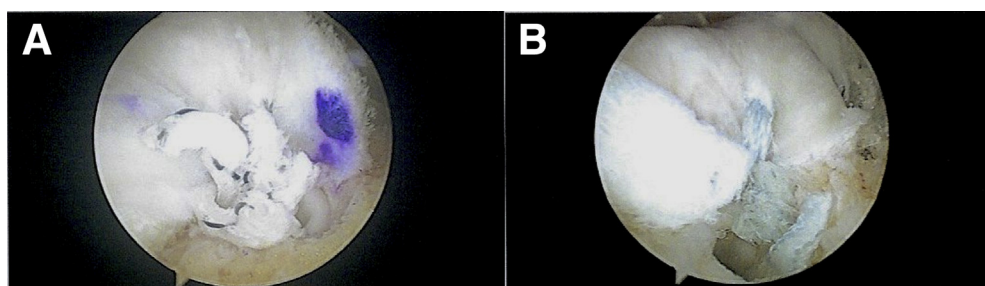


Figure 7. Right shoulder in the beach chair position viewing from the posterior portal within the subacromial space. (A) Anterior greater tuberosity fixation using Arthrex 4.75×19.1 -mm BioComposite SwiveLock C vented anchor after tails of TigerLink suture passed through anchor eyelet and appropriately tensioned. (B) Posterior greater tuberosity fixation using Arthrex 4.75×19.1 -mm BioComposite SwiveLock C vented anchor after tails of FiberLink suture passed through anchor eyelet and appropriately tensioned.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
<ul style="list-style-type: none"> • Perform efficient subacromial decompression for visualization • Use cannulas to prevent soft tissue bridges • Split the soft, lateral portal cannula to facilitate allograft passage into the shoulder • Pass all sutures into the allograft outside of the shoulder before graft shuttling • Incorporate residual rotator cuff into construct anterior and posterior to allograft wherever possible 	<ul style="list-style-type: none"> • Inadequate visualization • Failure to use cannulas • Improper suture management

preclude later conversion to RSA, increasing its appeal to delay total joint replacement as long as possible.

Other techniques using dermal allograft for SCR have been described, showing growing interest in the procedure among shoulder surgeons.^{14,16-18} These techniques vary in anchor placement, ranging from 2 to 3 glenoid anchors placed medially and graft fixation accomplished laterally using double-row methods. Other authors also described arthroscopic measurement of the rotator cuff defect for allograft preparation. In our experience, the anchor configuration and graft preparation technique described here afford efficient reconstruction without compromising humeral head coverage or depression, with operative times rarely exceeding 1-hour duration. This method for performing SCR has streamlined our procedure to ease suture management and graft passage, generally yielding reliable results in our current series of patients (Table 1).

This technique, however, has its limitations. As with any SCR technique, most authors would likely agree that the procedure is more technically challenging than a typical rotator cuff repair. This is due in large part to the arthroscopic visualization needed, the number of suture anchors required, suture management issues, and shuttling of a large allograft. Early in the procedure, an efficient subacromial decompression and acromioplasty greatly enhance visualization necessary to complete the procedure in a timely manner. Working through cannulas is also very important to avoid soft tissue bridges. Splitting the PassPort cannula longitudinally in the lateral portal is a pearl that greatly eases allograft passage into the shoulder.

Our technique differs from others described in a few major ways, which may also represent limitations

(Table 2). First, we use a standardized allograft size. Whereas other techniques measure the humeral head coverage defect and size their allograft accordingly, we find this potentially unnecessary. Currently, it is unclear whether the dimensions of SCR allograft affect patient outcomes. We do, however, feel that a standardized graft size increases efficiency and reproducibility of the procedure, which in turn results in a shorter operative time for the patient. Also, residual humeral head coverage defects can be managed by mobilization of the posterior rotator cuff tendon or subscapularis tendon to the allograft. Second, we use single-row fixation of the allograft on the greater tuberosity of the humerus. Although there is an effective argument for double-row rotator cuff repair from a biomechanical standpoint, clinical significance has been less clear.²⁴⁻²⁷ Also, it is currently unknown whether single- or double-row fixation of SCR allograft is biomechanically superior or affects patient outcomes, a potential topic for future investigation. We do theorize, however, that the inherent allograft strength, combined with the type of suture and suture anchors used in this technique, is adequate to achieve the desired clinical outcome.

The original report using SCR showed impressive clinical results of the procedure with a fascia lata autograft.¹⁵ That series found that 83% of patients had intact grafts, ascertained with postoperative imaging at an average follow-up of 34 months. The acromiohumeral distance increased from an average of 4.6 to 8.7 mm, suggesting a reversal of superior humeral head migration. Further, range of motion and clinical outcomes such as American Shoulder and Elbow Score (ASES) significantly improved over the substantial time period these patients were followed. Hirahara et al.²⁰

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none"> • Technique is all arthroscopic • Predetermined graft size increases efficiency • All sutures are passed through graft outside of shoulder • Medial graft fixation and split lateral cannula ease graft passage • Knotless single-row lateral fixation optimizes suture management and efficiency 	<ul style="list-style-type: none"> • Suture management • More technically demanding than typical rotator cuff repair

reported experience and 2-year clinical outcomes of a series of patients who had undergone SCR using dermal allograft. Mean acromiohumeral distance likewise increased from 4.5 to 7.6 mm at 2 years, significant improvements were accomplished in ASES and mean Visual Analog Scale (VAS) pain scores, and ultrasonography showed evidence of graft healing.²⁰ More recently, other authors have similarly reported satisfactory results with improved ASES and VAS scores, as well as increased acromiohumeral intervals.^{21,28} These represent encouraging outcomes and support for use of allograft in the SCR procedure. Recent clinical outcomes of SCR with fascia lata autograft by Mihata et al.²⁹ also continue to impress. In a 5-year follow-up report, the authors showed a continued improvement in outcome scores (ASES and Japanese Orthopedic Association scores) and acromiohumeral measurements at 5 years. Further, they reported very high rates of return to work and sport (92% and 100%, respectively) and maintained integrity of the graft in the majority of cases.²⁹

In conclusion, although it is a relatively new procedure, clinical and biomechanical outcomes of SCR show promise for management of irreparable rotator cuff tears. The technical demands of the SCR procedure require experience and familiarity with the currently available reported techniques. Clinically, the parameters to follow pre- and postoperatively may include detailed shoulder examination and validated function scores such as the VAS, ASES, and Single Assessment Numerical Evaluation (SANE) score for valuable information. Radiographic analysis including plain films measuring acromiohumeral distance and magnetic resonance imaging evaluating graft integrity may also play an important role in monitoring outcomes.

References

- Orr SB, Chainani A, Hippensteel KJ, et al. Aligned multilayered electrospun scaffolds for rotator cuff tendon tissue engineering. *Acta Biomater* 2015;24:117-126.
- Seidl AJ, Lombardi NJ, Lazarus MD, et al. Arthroscopic transosseous and transosseous equivalent rotator cuff repair: An analysis of cost, operative time, and clinical outcomes. *Am J Orthop (Belle Mead NJ)* 2016;45:E415-E420.
- Denard PJ, Lädermann A, Jiwani AZ, Burkhart SS. Functional outcome after arthroscopic repair of massive rotator cuff tears in individuals with pseudoparalysis. *Arthroscopy* 2012;28:1214-1219.
- Pedowitz RA, Yamaguchi K, Ahmad CS, et al. American Academy of Orthopaedic Surgeons Clinical Practice Guideline on: Optimizing the management of rotator cuff problems. *J Bone Joint Surg Am* 2012;94:163-167.
- Wolf BR, Dunn WR, Wright RW. Indications for repair of full-thickness rotator cuff tears. *Am J Sports Med* 2007;35:1007-1016.
- Audenaert E, Van Nuffel J, Schepens A, Verhelst M, Verdonk R. Reconstruction of massive rotator cuff lesions with a synthetic interposition graft: A prospective study of 41 patients. *Knee Surg Sports Traumatol Arthrosc* 2006;14:360-364.
- Derwin KA, Badylak SF, Steinmann SP, Iannotti JP. Extracellular matrix scaffold devices for rotator cuff repair. *J Shoulder Elbow Surg* 2010;19:467-476.
- Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. *J Bone Joint Surg Am* 2004;86:219-224.
- Harryman DT, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. *J Bone Joint Surg Am* 1991;73:982-989.
- Liu SH, Baker CL. Arthroscopically assisted rotator cuff repair: Correlation of functional results with integrity of the cuff. *Arthroscopy* 1994;10:54-60.
- Mulieri P, Dunning P, Klein S, Pupello D, Frankle M. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. *J Bone Joint Surg Am* 2010;92:2544-2556.
- Guery J, Favard L, Sirveaux F, Oudet D, Mole D, Walch G. Reverse total shoulder arthroplasty. Survivorship analysis of eighty replacements followed for five to ten years. *J Bone Joint Surg Am* 2006;88:1742-1747.
- Werner CM, Steinmann PA, Gilbart M, Gerber C. Treatment of painful pseudoparesis due to irreparable rotator cuff dysfunction with the Delta III reverse-ball-and-socket total shoulder prosthesis. *J Bone Joint Surg Am* 2005;87:1476-1486.
- Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthroscopy* 2013;29:459-470.
- Adams CR, Denard PJ, Brady PC, Hartzler RU, Burkhart SS. The arthroscopic superior capsular reconstruction. *Am J Orthop (Belle Mead NJ)* 2016;45:320-324.
- Petri M, Greenspoon JA, Millett PJ. Arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthrosc Tech* 2015;4:e751-e755.
- Thorsness R, Romeo A. Massive rotator cuff tears: Trends in surgical management. *Orthopedics* 2016;39:145-151.
- Tokish JM, Becker C. Superior capsule reconstruction technique using an acellular dermal allograft. *Arthrosc Tech* 2015;4:e833-e839.
- Denard PJ, Brady PC, Adams CR, et al. Preliminary results of arthroscopic superior capsular reconstruction with dermal allograft. *Arthroscopy* 2018;34:93-99.
- Hirahara AM, Andersen WJ, Panero AJ. Superior capsular reconstruction: Clinical outcomes after minimum 2-year follow-up. *Am J Orthop (Belle Mead NJ)* 2017;46:266-278.
- Pennington WT, Bartz BA, Pauli JM, Walker CE, Schmidt W. Arthroscopic superior capsular reconstruction with acellular dermal allograft for the treatment of massive irreparable rotator cuff tears: Short-term clinical outcomes and the radiographic parameter of superior capsular distance. *Arthroscopy* 2018;34:1764-1773.
- Ek ET, Neukom L, Catanzaro S, Gerber C. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: Results after

- five to fifteen years. *J Shoulder Elbow Surg* 2013;22:1199-1208.
23. Otto RJ, Clark RE, Frankle MA. Reverse shoulder arthroplasty in patients younger than 55 years: 2- to 12-year follow-up. *J Shoulder Elbow Surg* 2017;26:792-797.
 24. Mazzocca AD, Millett PJ, Guaniche CA, Santangelo SA, Arciero RA. Arthroscopic single-row versus double-row suture anchor rotator cuff repair. *Am J Sports Med* 2005;33:1861-1868.
 25. Denard PK, Jiwani AZ, Lädermann A, Burkhart SS. Long-term outcome of arthroscopic massive rotator cuff repair: The importance of double row fixation. *Arthroscopy* 2012;28:909-915.
 26. Millett PJ, Warth RJ, Dornan GJ, Lee JT, Spiegl UJ. Clinical and structural outcomes after arthroscopic single-row versus double-row rotator cuff repair: A systematic review and meta-analysis of level I randomized clinical trials. *J Shoulder Elbow Surg* 2014;23:586-597.
 27. Burkhart SS, Adams CR, Schoolfield JD. A biomechanical comparison of 2 techniques of footprint reconstruction for rotator cuff repair: The SwiveLock-FiberChain construct versus standard double-row repair. *Arthroscopy* 2009;25:274-281.
 28. Burkhart SS, Prankun JJ, Hartzler RU. Superior capsular reconstruction for the operatively irreparable rotator cuff tear: Clinical outcomes are maintained 2 years after surgery. *Arthroscopy* 2019;6:373-380.
 29. Mihata T, Lee TQ, Hasegawa A, et al. Five-year follow-up of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *J Bone Joint Surg Am* 2019;101:1921-1930.